

# *The Global Precipitation Measurement (GPM) Mission: An Overview*

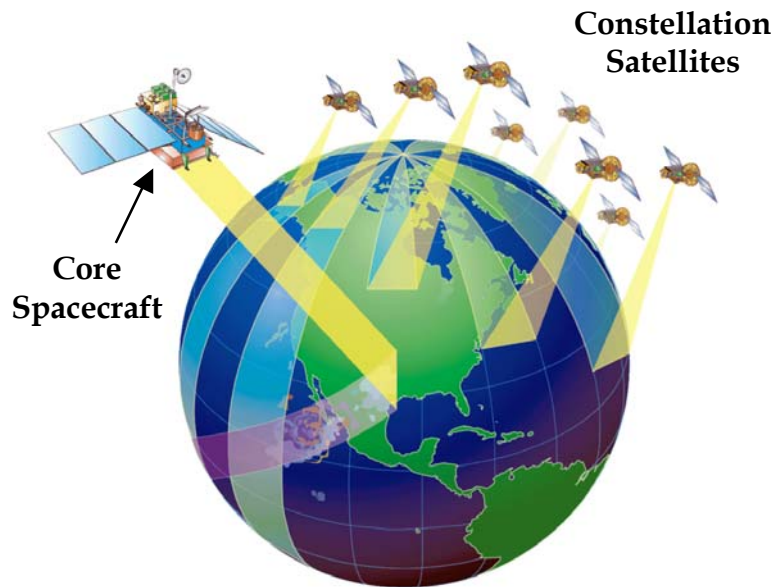
*Arthur Y. Hou*

*NASA Goddard Space Flight Center  
arthur.y.hou@nasa.gov*



*Mission Concept  
Instrument Capabilities  
Ground Validation  
Scientific and Societal Benefits  
Status*

EGU General Assembly 2006, Vienna, Austria, 2-7 April 2006

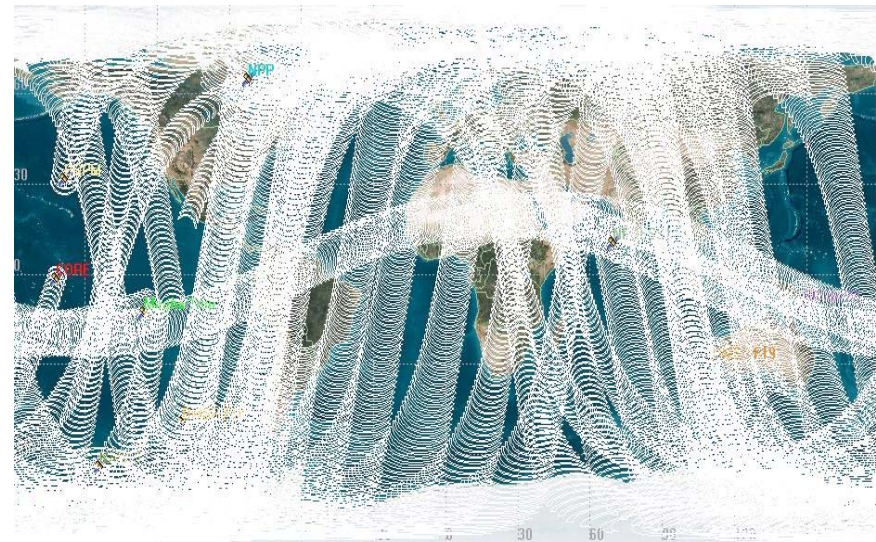


*GPM is an international satellite mission using combined **active & passive microwave sensors** to provide **accurate precipitation measurements** around the globe approximately every 3 hours*

*The GPM constellation comprises dedicated and operational satellites:*

*GPM Core, F18, F19, GCOM-W  
Megha-Tropiques, NASA-1  
Partner-1 (NPOESS-1)  
Partner-2 (EGPM, NPOESS-2)*

**GPM Core + 7 Constellation 3-Hour Coverage**



# GPM Science Objectives

- *Advancing precipitation measurement capability from space*  
through combined use of active and wide-band passive remote-sensing techniques
- *Advancing understanding of global water/energy cycle variability and fresh water availability*  
through better measurement of the space-time variability of global precipitation
- *Improving weather forecasting skills*  
through more accurate and frequent measurement of instantaneous rain rates
- *Improving climate modeling & prediction capabilities*  
through better understanding of precipitation microphysics, surface water fluxes, soil moisture storage, and atmospheric latent heating distribution
- *Improving prediction capabilities for floods, droughts, fresh water resources, crop conditions, & other hydrological applications*  
through improved temporal sampling and high-resolution spatial coverage

*A science mission with integrated applications goals.  
Achieving these science objectives directly leads to societal benefits.*

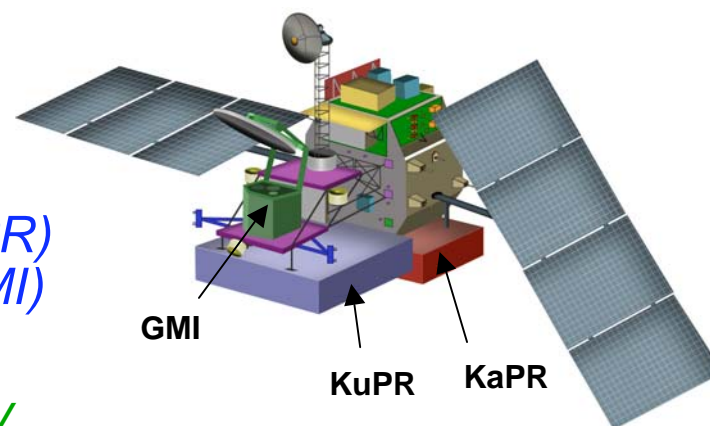
# GPM's Dual Role in Global Precipitation Measurement

## ➤ *Providing a Calibration Standard for Improved Accuracy:*

GPM Core Spacecraft will carry

- a JAXA-provided dual-frequency radar (DPR)
- a NASA-provided microwave imager (GMI) with HF capabilities

to serve as *a precipitation physics observatory* and *a calibration standard* to unify a heterogeneous constellation of radiometers.



## ➤ *Optimizing Global Coverage & Sampling:*

- a NASA-provided “wild card” constellation satellite with a GMI

to maximize the coverage and sampling by the constellation satellites.



# Unification of a Heterogeneous Constellation of Radiometers

## Constellation radiometer assets channel coverage

Channel	6 GHz	10 GHz	19 GHz	23 GHz	36 GHz	50-60 GHz	89 GHz	150/166 GHz	183 GHz
AMSR-E	6.925 V/H	10.65 V/H	18.7 V/H	23.8 V/H	36.5 V/H		89.0 V/H		
CMIS	6.625 V/H	10.65 H/R/L	18.70 V/P/M/R/L	23.8 V/H	36.5 V/P/H	50.3-60.44 V/L	89.0 V/H	166 V	183.31 V
GMI		10.65 V/H	18.70 V/H	23.80 V	36.50 V/H		89.0 V/H	165.5 V/H	183.31 V
MADRAS			18.7 V/H	23.8 V	36.5 V/H		89 V/H	157 V/H	
SSMIS			19.35 V/H	22.235 V	37.0 V/H	50.3-63.28 V/H	91.65 V/H	150 H	183.31H

V – Vertical Polarization      L – Left Circular Polarization  
 H – Horizontal Polarization      P – Plus 45 degrees  
 R - Right Circular Polarization      M – Minus 45 degrees

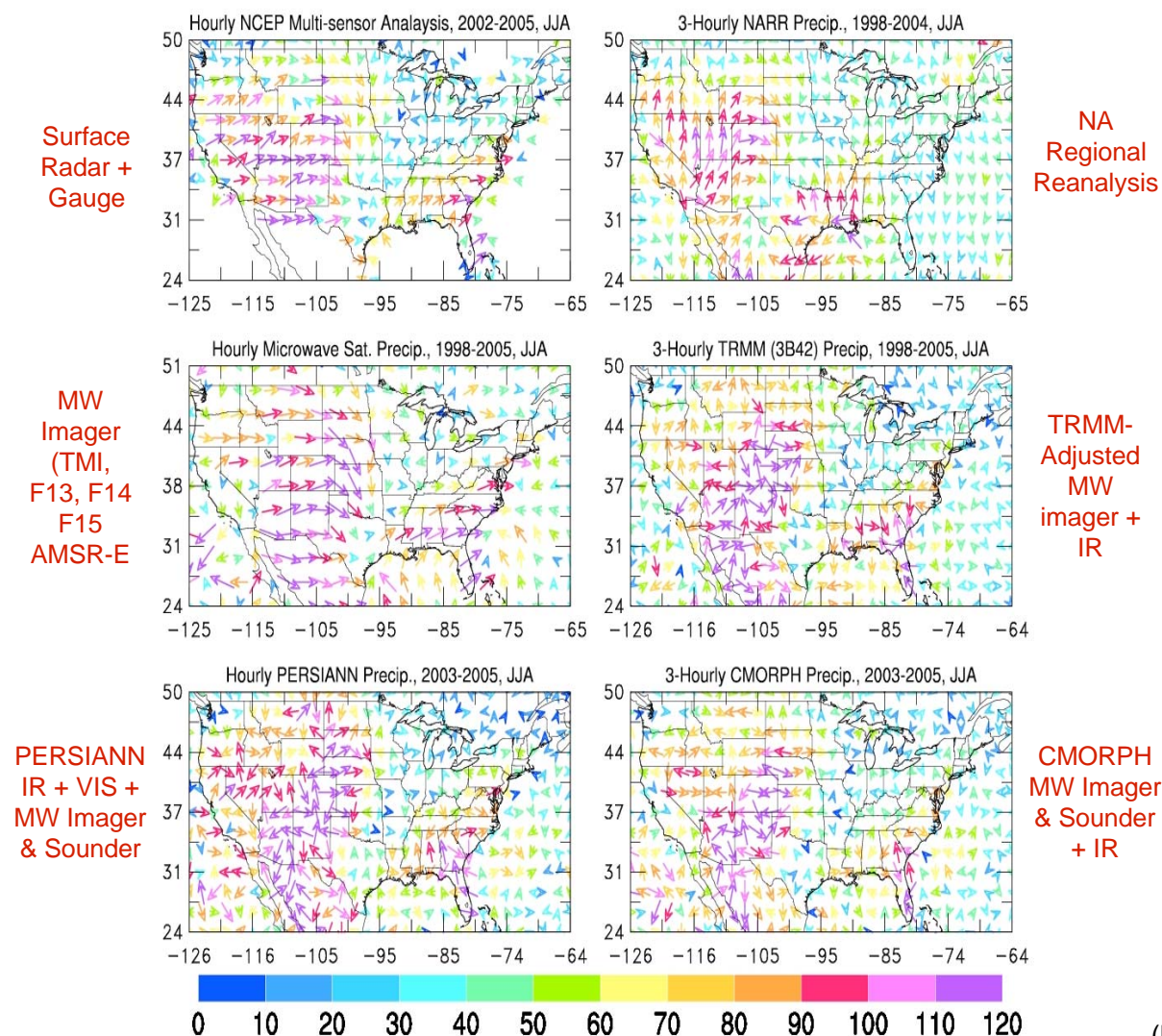
## Mean Spatial Resolution (km)

Channel	6 GHz	10 GHz	19 GHz	23 GHz	36 GHz	50-60 GHz	89 GHz	150/166 GHz	183 GHz
AMSR-E	56	38	21	24	12		5		
CMIS	54	38	20	15	14	14	14	14	14
GMI		26	15	12	11		6	6	6
MADRAS			40	40	40		10	6	
SSMIS			59	59	36	22	14	14	14

*DPR/GMI on GPM Core provides a uniform calibration of  $T_b$  and a common database for precipitation retrieval for dedicated and operational sensors*

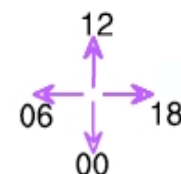
# Current capability of Multi-Sensor Precipitation Products

## Normalized Diurnal Harmonic Amplitude



Courtesy of A. Dai/NCAR

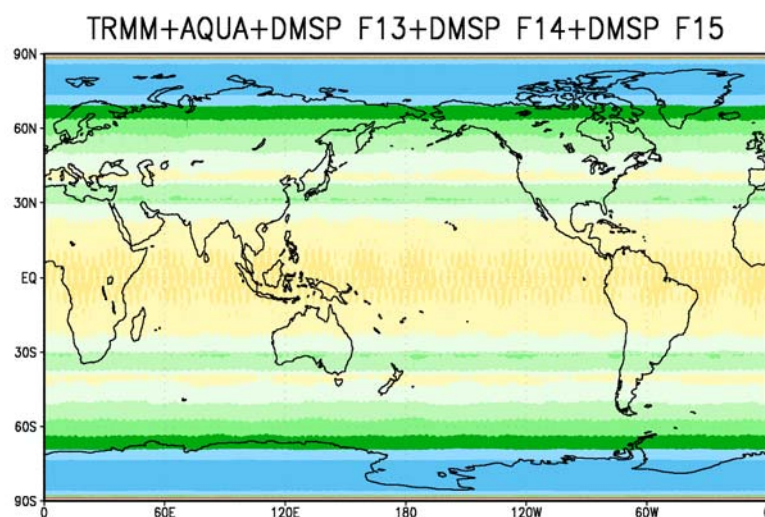
*GPM will provide more accurate global precipitation analysis through better calibration, sampling, and uniform retrieval procedures.*



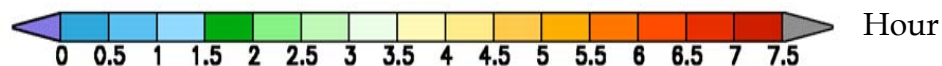
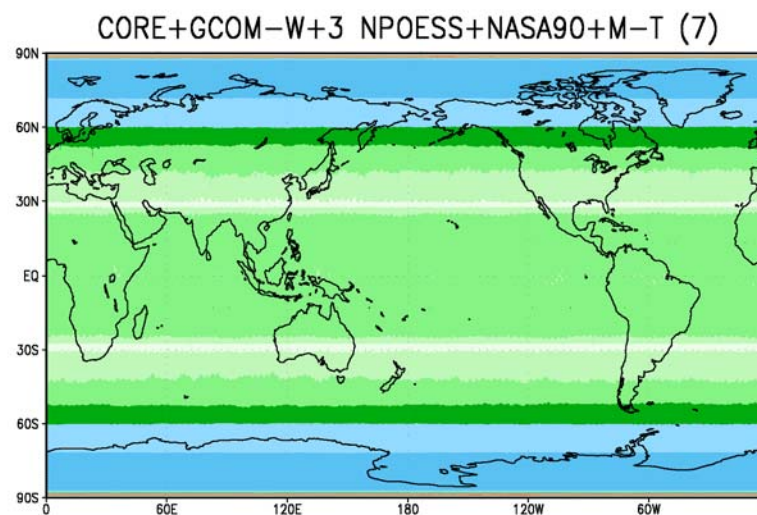
Phase Clock  
(Local Standard Time)

# Average Revisit Times by Passive Microwave Radiometers

Current:  
( $\leq 3$ h over 34.6% of globe)



GPM-Era:  
( $\leq 3$ h over 96.0% of globe)

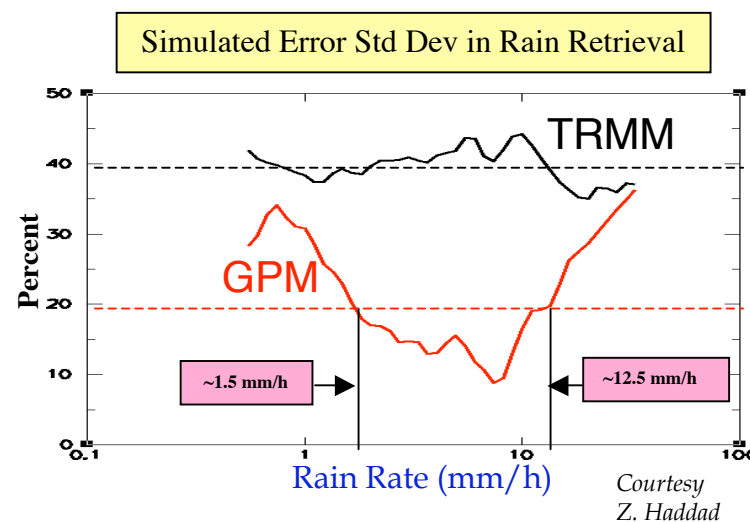
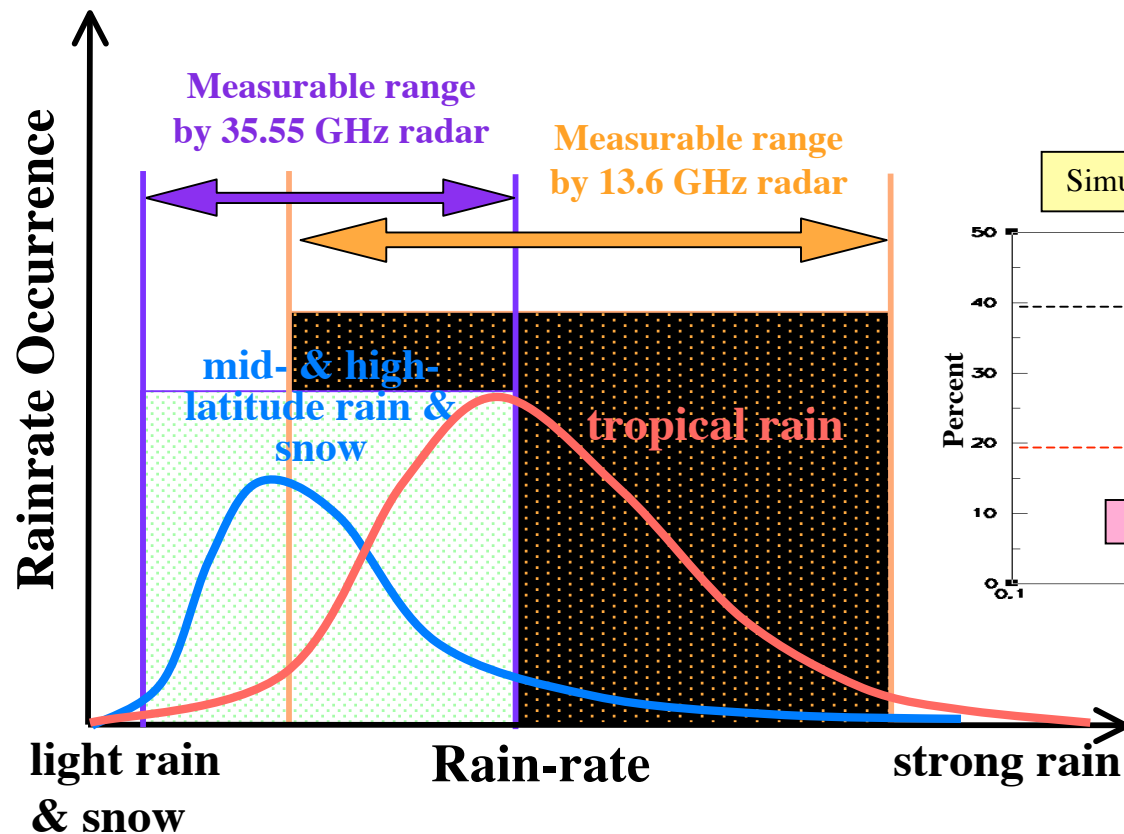


TRMM, Aqua F13, F14, F15

GPM Core, GCOM-W, NASA-1  
Megha-Tropiques, 3 NPOESS's

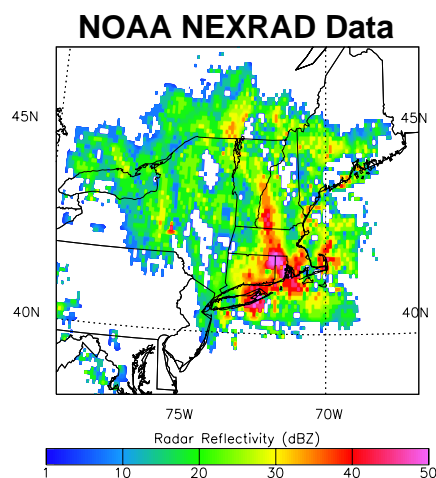
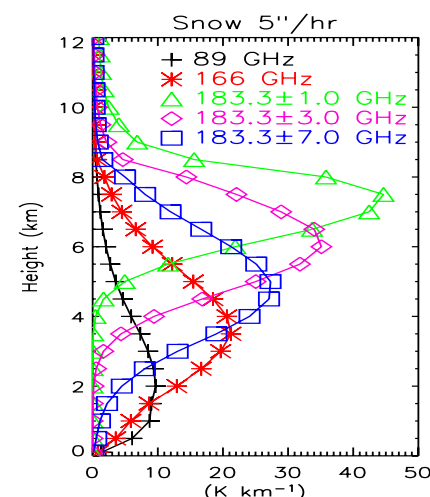
# JAXA/NICT Dual-Frequency Precipitation Radar

- *Increased sensitivity for light rain and snow detection* – extending the detection threshold from 18 to 11 dBZ (0.5 to 0.17 mm/h)
- *Better overall measurement accuracy* - replacing the surface reference technique for path-integrated-attenuation correction with dual-frequency methods
- *More detailed microphysical information* – estimation of drop size distribution, etc. to improve cloud database for Core and constellation radiometer retrievals

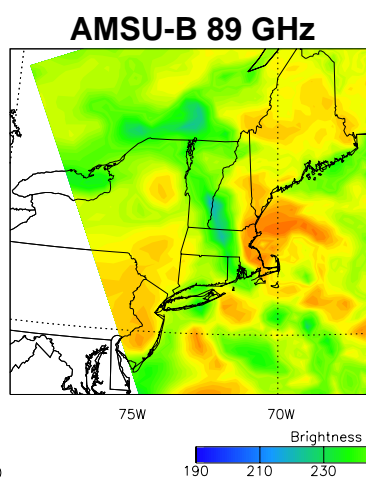


# Science Values of HF Capability on GMI

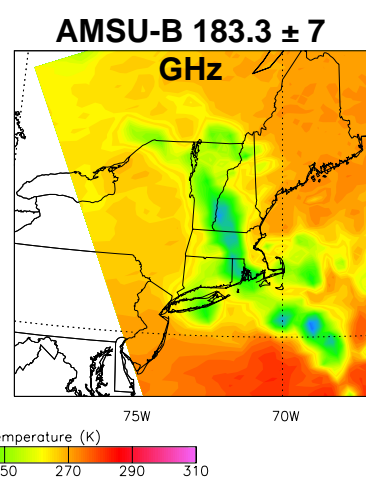
- Measure light rain
- Measure frozen precipitation
- Improve retrieval algorithms over land
- Enable the testing and evaluation of constellation radiometer algorithms using the DPR on GPM Core



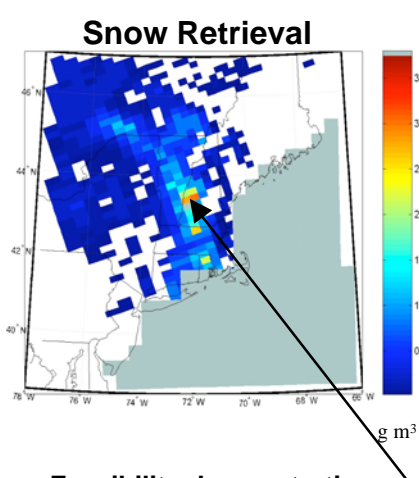
Radar reflectivity composite of the March 5-6, 2001 New England blizzard (75 cm of snow fell on Burlington, VT)



Surface effects evident over the Great Lakes, the St. Lawrence River, and along the Atlantic coast. Cannot distinguish surface from cloud effects.



Surface effects screened by water vapor. Snowfall appears over New England as low brightness temperatures



Feasibility demonstration of snowfall retrieval using 4 in/hr HF channels

G. Skofronick-Jackson et al. (GSFC)

# GPM Ground Validation Strategy & Plans

- *Statistical validation sites for direct assessment of GPM satellite surface precipitation products:*

- Co-located with existing or upgraded national network (NEXRAD etc.) and dense gauge networks to identify and resolve significant discrepancies between the national network and satellite estimates
- Leveraging off national networks of partnership countries and international scientific collaboration for regional and global assessments

- *Precipitation process sites for improving understanding and modeling of precipitation physics in physical and radiance spaces for satellite retrieval algorithm improvements:*

- Continental tropical, mid- and high-latitude sites (including orographic/coastal sites and targeted sites for resolving discrepancies between satellite algorithms)
- Oceanic tropical and mid-latitude sites
- Aircraft measurements

- *Integrated hydrological sites for improving hydrological applications:*

- Co-located with existing watersheds maintained by other US agencies and international research programs to use hydrological basins as an integrated measure of the quality of precipitation products

*International GPM GV partnership opportunities*

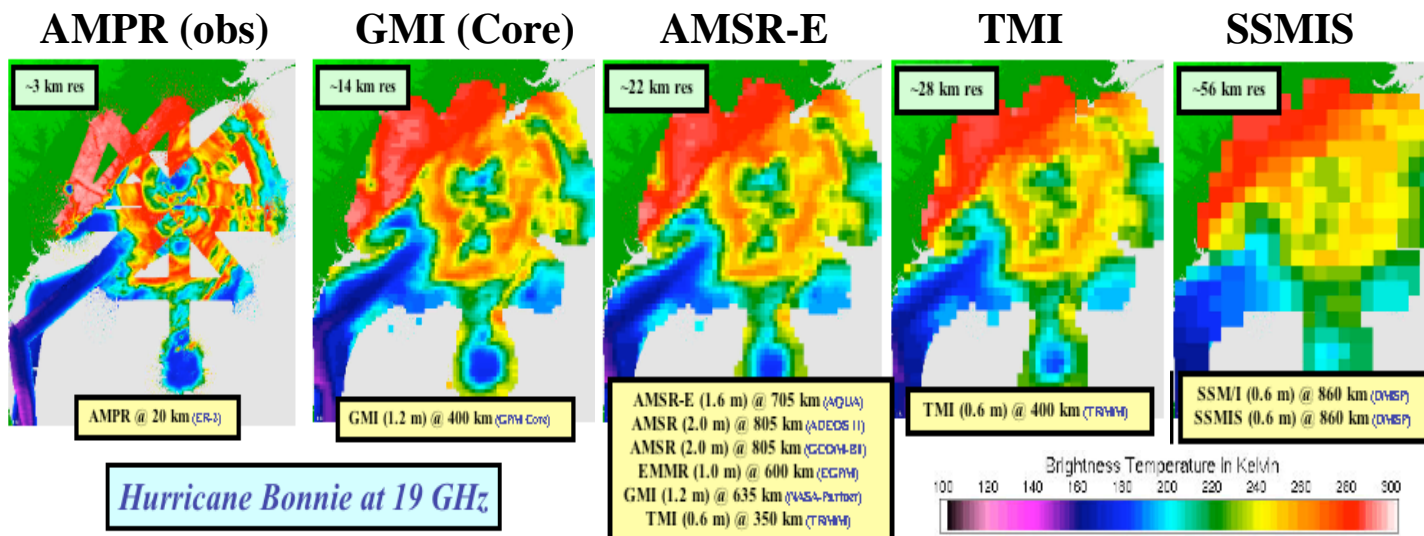
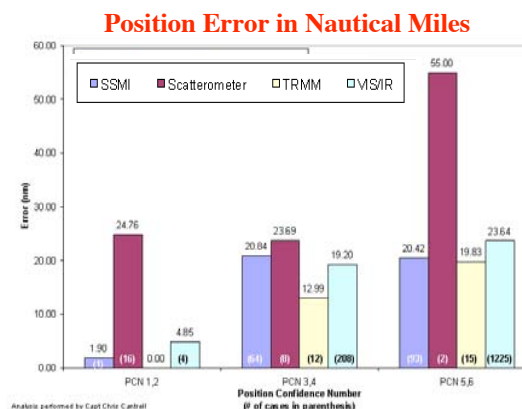
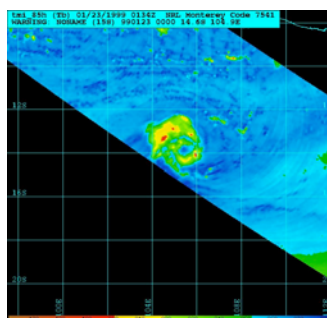
# GPM Expected Benefits - I

## Direct benefits of observations of precipitation intensity and structure:

- Monitoring extreme precipitation events and freshwater availability
- Improving position fix for typhoon/hurricane predictions

Higher-resolution GPM radiometer data can provide better position fixes in early stages of storm development

TMI 85GHz Image of enclosed eye with spiral bands



Synthesized  
Brightness  
Temperatures  
(R. Hood  
NASA/MSFC)

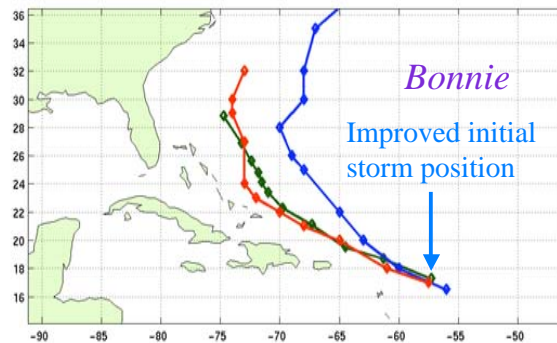


## GPM Expected Benefits – II

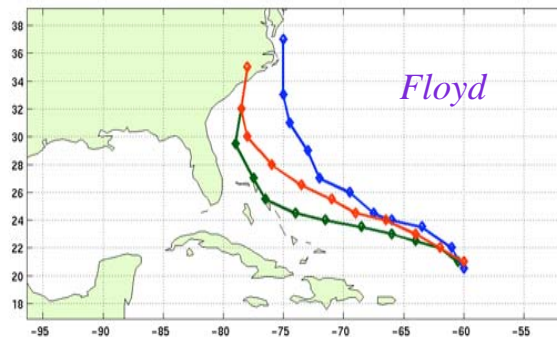
- **Numerical Weather Prediction** – Provide swath brightness temperatures and rain rates to operational NWP centers to improve forecast skills

NASA/GEOS-3 Hurricanes Bonnie and Floyd forecast improvements

5-day track forecast from 12UTC 8/20/98



5-day track forecast from 00UTC 9/11/99



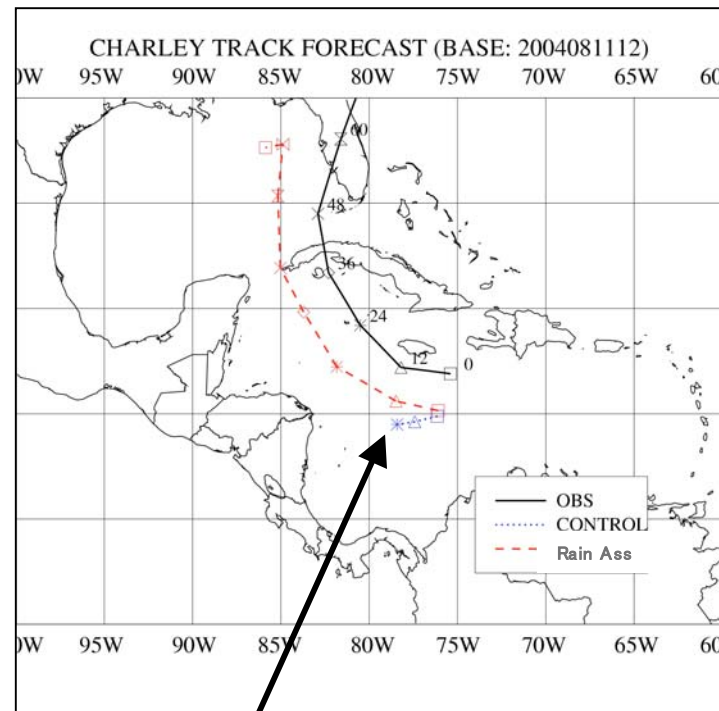
Green: NOAA “observed track”

Blue: Control forecast without rainfall data

Red: With TMI+SSM/I rainfall data in IC

Hou et al. (2004)

ECMWF Hurricane Charley track forecasts from analysis 2004081112



**Cyclone disappeared in operational forecast without rain assimilation**

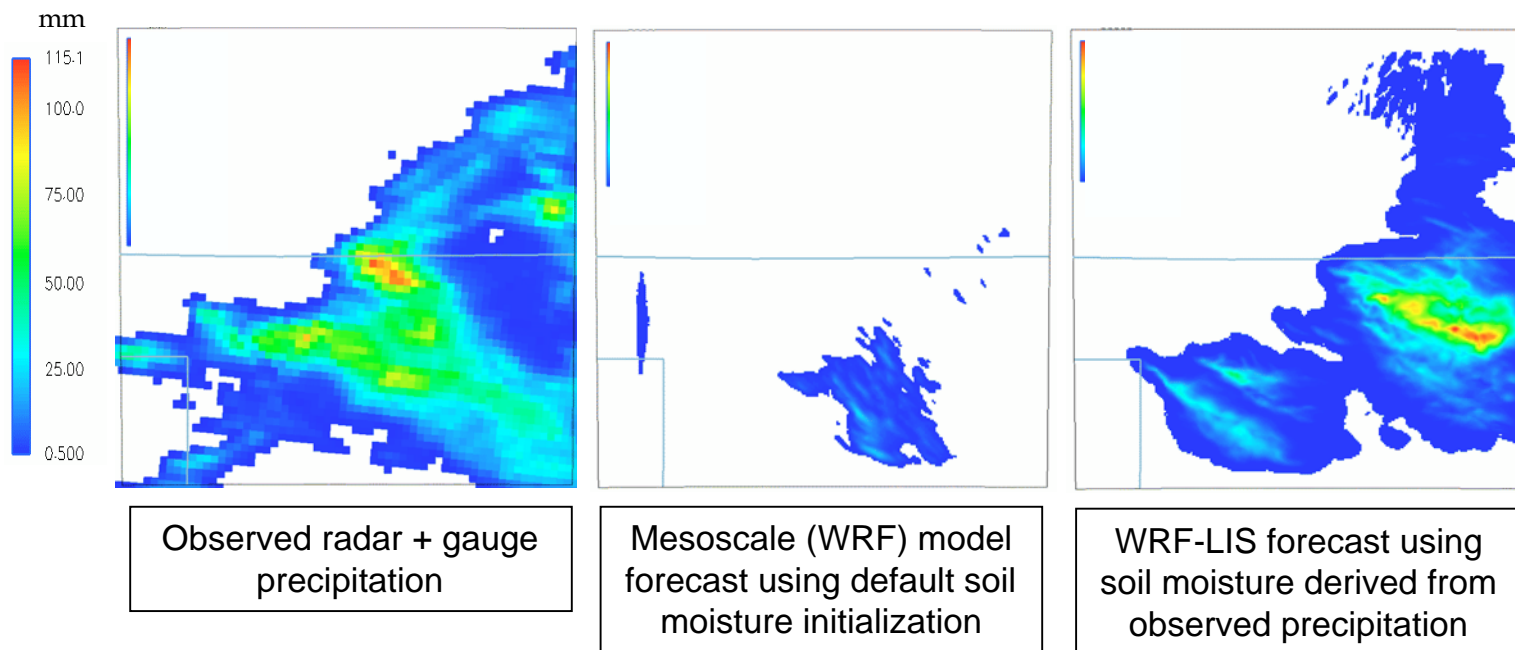
Courtesy of P. Bauer/ECMWF

## GPM Expected Benefits – III

- **Hydrological Prediction** – Provide 3-hour rainfall products to operational agencies to improve hydrological modeling and prediction

Impact of improved soil moisture using observed surface rainfall on precipitation forecast, June 12-13, 2002

24 Hour Accumulated Precipitation (mm)



Courtesy of C. Peters-Lidard/NASA

## *GPM Expected Benefits – IV*

- **Applications** – *Make GPM data products and resources accessible to users and stakeholders beyond the traditional precipitation science community:*

- Freshwater Utilization and Resource Management
- Natural Hazard Monitoring/Prediction (Flood Warnings, Hurricane and Cyclone Observation, Winter Weather Events)
- Crop Monitoring
- Climate Change Assessment
- Policy and Planning



- **Outreach** – *Make immediate precipitation data products available to:*

- Students, teachers, and researchers in educational institutions via direct network access to GPM data products
- Commercial and public television enterprises via near-real time graphic rain imagery
- Any government, industrial, and academic users as well as private homes

# GPM Status

- *Programmatic*

- In Formulation at NASA and JAXA (Phase B)
- GPM Microwave Imager (GMI) in development by Ball Aerospace Technology Corporation
- Joint NASA and industry development of Core Spacecraft underway
- JAXA Dual-frequency Precipitation Radar development proceeding
  - KuPR and KaPR engineering model under development & testing
- Target Launch Date: ~ 2012 timeframe

- *Domestic and International Partnerships*

- NASA-JAXA Memorandum of Understanding (MOU) for Formulation Phase signed and implemented in July 2005.
- 5th GPM International Planning Meeting held in November 2005 in Tokyo, Japan. *The next meeting is being planned for late 2006.*
- 2nd GPM International Ground Validation Workshop held in September 2005 in Taipei, Taiwan. *The 3rd GV Workshop is under planning for 2007.*
- Additional international partners in spacecraft, instrument, and ground validation assets are under discussion.

# International Partnership: Key to GPM Success

## GPM

- *Building on*
  - the success of TRMM
  - NASA and JAXA capabilities in precipitation measurements from space
  - national and international partnerships in satellite constellation formulation and ground validation
- *GPM was identified by United Nations in 2002 as an outstanding example of peaceful uses of space - benefiting international scientific community and enabling important societal applications involving freshwater resources and environmental prediction.*
- *GPM implementation approach is prototype for the emerging Global Earth Observing System of Systems (GEOSS), an international effort to provide comprehensive, long-term, and coordinated observations of the Earth.*

